Carbonate Assimilation in Open Magmatic Systems: the Role of Melt-bearing Skarns and Cumulate-forming Processes

Model for a reactive assimilation process

Effect of OCC zone on magmatic differentiation

Our model of a reactive assimilation process involving the CaO-rich silicate melt (AH3AX65 in Table 6) and the leucite basanite parental magma (LBSN in Table 10) in the OCC zone is illustrated schematically in Fig. 13 [using nomenclature according to Marsh (1995)].

According to this model at time t_0 a parental magma [PM in reaction (4), corresponding to leucite basanite in Fig. 13] is emplaced into limestone wall-rocks. At time t_1 an endoskarn zone forms and the magmatic system is characterized by a 'suspension' of olivine crystals [Fo_{90} in reaction (4) and Fig. 13] and a 'free' magma. At time t_1+dt the magma zone close to the wall-rock reaches the clinopyroxene saturation temperature (1180°C in Fig. 13); under these conditions, both olivine and clinopyroxene are stable. At this stage, the magmatic system is made up of three zones: free magma, Fo_{90} suspension, and olivine+clinopyroxene mush [Fo_{90}+Di and Cpx_R in Fig. 13]. In particular, the Cpx_R zone forms when the intercumulus melt (in the olivine+clinopyroxene mush) becomes olivine-undersaturated as a consequence of CaO-rich silicate melt assimilation. This results in the crystallization of poikilitic clinopyroxene and dissolution of olivine, according to reaction (4) and the O_{90}CC heteradcumulate texture. At time t_2 the intercumulus melt in the olivine+clinopyroxene mush has a composition intermediate between trachybasalt and phonotephrite, and Fo_{90} olivine is no longer stable. At this stage the O_{90}CC mush stops forming and Fo_{88} olivine starts to crystallize. Between time t_2 and t_3, the O_{88}CC forms and eventually (at t_3), the magmatic system becomes unstable and the phonotephritic Fo_{88}-bearing magma erupts. If we assume a short time interval between t_1 and t_2, trachybasaltic and/or less differentiated melts remain as free, 'eruptible' magmas for a very short period. This assumption could explain the absence in the CAVD stratigraphic record of primitive volcanic products.

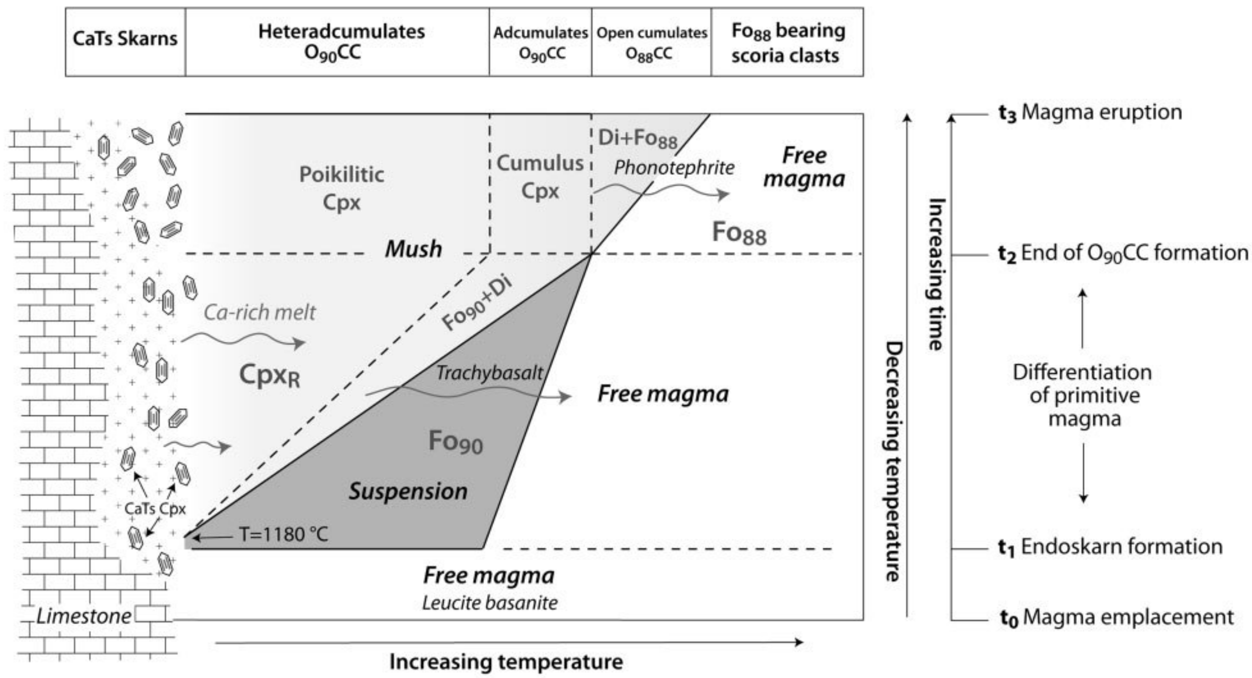

Fig. 13. Sketch of the spatial and temporal relationships between limestone, endoskarn, OCCs and free magma in the CAVD pre-eruptive system. The diagram illustrates the reactive assimilation process involving CaO-rich silicate melt (AH3AX65 in Table 6) and the leucite basanite parental magma (LBSN in Table 10) in the reaction-cumulate zone. This process results in an enlargement of the clinopyroxene stability field and the differentiation of primitive intercumulus melt according to equation (4). Liquidus phases in the cumulate zone are a function of degree of cooling, position with respect to the endoskarn front, and time (or melt differentiation); 1180°C indicates the point (at P=300 MPa, fO_2=NNO and H_2O=3 wt%) at which the magmatic system becomes saturated in olivine and clinopyroxene and changes its rheology from a suspension to a mush (Marsh, 1995). CpxR represents the zone of olivine-clinopyroxene mush where, as a result of the assimilation of CaO-rich silicate melt, the intercumulus melt becomes olivine-undersaturated.